The role of living kin in later life survival: Evidence from Finnish historical data

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Introduction

The rapid aging of Western populations has inspired researchers to explore the role of family members in the life of older adults. Informal family care which, due to limited access to information about actual care, is commonly approximated by different measures of family structure—particularly, being married (Rendall et al., 2011; Franke & Kulu, 2018; Kravdal et al., 2018) or having children and siblings (Perls et al., 2002; Keizer et al., 2012; Einiö et al., 2016)—was found to have a protective effect on later life survival, especially when public policies are lacking (Giudici et al., 2019).

Family members are assumed to be important for older adults because their presence is associated with the availability of emotional and instrumental support, as well as better regulation of health-related behaviors and increased opportunities for social integration, which are beneficial for promoting better physical and mental health among the older population [see, for example, Gellatly & Störmer (2017); Waite & Lehrer (2003), Monden et al. (2003), Lindström (2009), Grundy & Tomassini (2010)]. Family members may also provide a sense of meaning for older adults, which may improve survival (Taylor et al., 2019). At the same time, any positive associations between kin and longevity are likely to be driven by selection into marriage, (Wiik & Dommermuth, 2014), with its strong links to subsequent fertility outcomes (Syse et al., 2022). These positive associations may also be caused by underlying genetic propensities, for instance so that healthier lineages have higher fertility in several family generations, while others have high-mortality clustering, leading to differential survival of kin in later life (Van Dijk & Mandemakers, 2018; Van den Berg et al., 2019). Irrespective of the mechanism, contemporary societies exhibit positive associations between the presence of different types of family members and survival, raising the question of whether the same patterns persisted in preindustrial populations and whether having kin is as important for survival as having a spouse, the beneficial role of which seems to be universal in pre-industrial and modern Western societies (Drefahl, 2012; Gellatly & Störmer, 2017).

While today in developed countries the nuclear family as well as older adults' ageing in assisted facilities are considered the norm, historically and in many other cultural contexts it is the exception (Kramer, 2021). Older people were an integral part of the families and extended families with multigenerational co-residence were common. Also, other close relatives often lived nearby, promoting the support given to the elderly. Grandparents were important caregivers to the families of their adult offspring, and their presence has been linked to improved survival of grandchildren in previous studies in historical populations (e.g. Lahdenperä et al., 2004; Chapman et al., 2021; Sear & Mace, 2008; Sear & Coall, 2011). The research is scarce on the relationship between older adults' survival and the presence of relatives beyond children although research in historical as well as

traditional contexts could enhance our understanding of the costs and benefits that arise from the organization of modern households and offer a broader perspective of human family life. Addressing this research gap, we aim to quantify *the presence (i.e. being alive) of children, siblings, and grandchildren in later life in a pre-industrial population of Finland, explore the relationship between their presence and the risk of death for men and women after 50 years,* and *test whether the role of children and siblings varies with age*. Additionally, we *explore how lacking a spouse and children, whose role in later life is likely greater in comparison with other family members, shapes the relationship between presence of siblings and the risk of death*. To answer these questions, we draw on historical population registry data about men and women born between 1740-1859 in Finland and utilize multilevel discrete-time hazard models for mortality at age 50–90.

Background and hypotheses

Close family members, such as children as siblings, can provide support in later life. Researchers often highlight a protective role of children for the mortality of older people (see, for example, Christiansen, 2014; Einiö et al., 2016; Giudici et al., 2019). Unlike their peers without children, mothers and fathers may enjoy social and financial support and later life care provided by their children (Grundy & Kravdal, 2010). Although sibling ties may not be as duty-bound as ties between parents and children, siblings do appear to provide help and care when needed (Buchanan, 2021; Connidis, 1994; Eriksen & Gerstel, 2002). Sibling presence was found important for older adults' mortality risks in a contemporary population (Patterson et al., 2020). Based on these findings, we formulate our main (family support) hypothesis: *Having at least one living child or at least one living sibling will be associated with a reduced risk of death* in later life (Hypothesis 1).

In addition to the vital statuses of family members, another factor that might relate to the risk of death is the potential of these family members to provide support. Compared with men, women generally provide more care (Queller, 1997), and this concerns both daughters versus sons (Haberkern et al., 2015; Silverstein et al., 2006) and sisters versus brothers (Buchanan & Rotkirch, 2021). In some historical societies, the youngest daughter was expected to remain in her parents' home and postpone or give up marriage to care for her parents into their old age (Hareven, 1994). However, it does not mean that male relatives are not important: Studies have shown that men take responsibility for providing instrumental support (Rossi & Rossi, 1990; Brandt et al., 2009) that might be important for survival, especially in the pre-industrial period. Among studies addressing the long-term costs and benefits of bearing and raising children, maternal longevity was found to be negatively related to bearing sons (Helle et al., 2002; Van De Putte et al., 2004) and positively related to bearing daughters (Beise & Voland, 2002; Helle et al., 2002; Jasienska et al., 2006: for fathers only), but studies on the

role of living sons and daughters during older adulthood on parental survival are more rare. Pham-Kanter and Goldman (2012) showed that daughters can be more beneficial than sons in reducing parental mortality. Other aspects of the caregiving potential of kin are structural. First, it might be more beneficial to have children of different sex, since they can provide different types of support (Rossi & Rossi, 1990). Second, theoretically, the size of the group of relatives might matter: The more alternative caregivers one has, the more efficient the caregiving can be. Regarding the siblings' sex and number, having (older) brothers present in later life was found to be associated with high excess mortality risk for both sexes, though men were more strongly disadvantaged, and having (more) sisters was related to significantly lower mortality risk for women (Donrovich et al., 2014). Summarizing these aspects of family members' caregiving potential, we hypothesize: *Those with at least one living daughter or sister and those with mixed sex group of more than two children or siblings will have a lower risk of death than those with no children or siblings* (Hypothesis 2).

The importance of family caregivers for survival is likely to increase with older adults' age. The degree to which care is provided represents a function of the needs that older people have (Kalmijn & Saraceno, 2008), e.g., when parents' health deteriorates with increasing age, their children respond by providing more care (Knijn & Liefbroer, 2006). One study found that the presence of children was associated with increased parental longevity, and this association increased with parental age (Modig et al., 2017). In a similar way, the importance of siblings is not stable over the life course: While both sibling interaction and sibling competition are most intense during childhood, they are typically followed by a decrease in contact, exchange of help, and proximity during young adulthood, a stabilization of contact in middle life, and a rise in exchange of help later in life (White, 2001). This intensification in help is caused by transitions (e.g., losing a partner, worsening health) that later life brings (Connidis, 1992; Gold, 1987). We, therefore, hypothesize: *Having at least one child or sibling, especially a daughter or a sister who is more likely to provide support, will become increasingly advantageous for survival with age* (Hypothesis 3).

Family embeddedness—i.e. cross-classification of network members available in different statuses, for instance, having a partner, children and siblings vs. having only siblings (Patterson et al., 2020)—may also be associated with mortality. The substitution hypothesis (Shanas, 1979) and the hierarchical compensatory model (Cantor, 1991) suggest that older adults in contemporary Western societies rank their sources of support according to a common order of preference and availability. The first choice for assistance is the spouse, who is usually the main provider of support in everyday life and during illness as well as the manager over health behaviors (Kravdal et al., 2018). As a result, marriage is universally positively associated with longevity (Rendall et al. 2011), particularly for men (Gellatly & Störmer, 2017). If a spouse is unavailable, older adults turn to children and other relatives,

including siblings. Building on the family embeddedness perspective, we hypothesize: *The role of children and siblings for survival will be greater in the absence of a spouse* (Hypothesis 4a) and *the role of siblings will be greater in the absence of a spouse and children* (Hypothesis 4b).

Other mechanisms than family support may regulate the relationship between the presence of kin and later life survival. Competition for the family resources could be one of them, especially in pre-industrial populations. Such competition is driven by parent-offspring conflict and sibling competition. In a study from pre-industrial Sweden, the number of children ever born had a statistically significant negative impact on longevity after age 50, but only for landless women (Dribe, 2004). A study based on the historical Utah population (the US) shows that having mostly sons continued to be associated with excess maternal mortality regardless of whether children survived to adulthood and, with advancing age, the negative effect of having mostly sons grew for mothers, whereas no effects were found for fathers (Harrell, 2008). Van de Putte and colleagues (2004) report a negative effect of sons on maternal longevity, mainly for mothers belonging to the lower social class, and for sons surviving their fifth birthday in pre-industrial Belgium. The authors proposed that male-dominated intra-household resource competition could explain their results. This interpretation implies that the higher cost of having sons was not so much due to pregnancy as to the fact that sons above a certain age were able to claim a serious amount of resources that depleted maternal resources. A study by Donrovich and colleagues (2014) provided evidence of a lasting impact of brothers' competition on the mortality risk over age 50 in Belgium in the 19th century, although the authors admit that the competition was replaced by solidarity in critical times, for instance when one brother became widowed. Building on these findings and the assumption that the echo of sibling competition can be seen in family relations in later life, we formulate an alternative (competition) hypothesis: *Having several living sons for women and several living brothers for both men and women relative to having no male kin of these types will be associated with an increased risk of death* (Hypothesis 5).

In addition to children and siblings, grandchildren might matter for later life survival, although the mechanism is not clear. On the one hand, according to Garay and colleagues' (2018) who introduced the evolutionary rationale for caring for older parents, adult children can be more interested in sharing their resources with parents if they need grandparental childcare from them. On the other hand, older people and their grandchildren might compete for the family resources and, potentially, affect each other's survival. In line with this, for infants, co-residing with grandfathers was associated with lower chances of survival (Chapman et al., 2023) and co-residence with old paternal grandmothers decreases grandchild survival (Chapman et al., 2019). Based on these

contrasting insights, we broadly hypothesize: *Having at least one grandchild will be associated with a risk of death* (Hypothesis 6).

Later life survival might be linked to determinants not directly related to kin presence. Birth order is one of such determinants (Noghanibehambari & Fletcher, 2023). First, compared to only children and firstborns, individuals of higher birth order need to compete for parental resources with one or more siblings who have already access to these resources. Second, typically for the period of our study, the oldest son (or the firstborn daughter and her husband) inherited parental property (Moring, 2002). In line with these assumptions about privileged access to resources, being the first-born was most beneficial for survival in Belgium of the 19th century even after the age of 50, implying that this advantage is lifelong (Donrovich et al., 2014). Moving away from the birthplace could be another determinant. Sibling dispersion is common, especially due to marriage or search for a better livelihood, and hence not all children can similarly assist their parents in old age. The simple presence of kin is not enough for providing support that, theoretically, can reduce the risk of death in later life: Family members need to live close enough for extensive support exchange (Knijn & Liefbroer, 2006). As family geographic proximity results from life-cycle mobility (Lin & Rogerson, 1995), we control for having moved away from the birth parish as we do not have the geographic distances between family members. However, it is worth considering that migration can relate to the risk of death in another way: It might be a strategy to search for the environment beneficial for survival (Brockerhoff, 1994).

Other determinants—socioeconomic status, the region and period of birth—should be discussed in the Finnish context. In pre-industrial Finland, where wealth existed mainly in the form of land, socioeconomic status shaped the household structure which could impact our results: Three-generational households were common among wealthy individuals while nuclear families were more common among poorer groups (Moring, 2003). Older individuals with land were also more likely than the landless to have retirement contracts i.e., agreements between aged farmers and their family members, usually children, claiming the transfer of property in return for food and support until the end of life. The landless, in turn, had little to give their children to compensate them for care in old age and could not expect extensive support from them due to the lack of resources (Moring, 2002). Still, it is difficult to predict the effect of socioeconomic status on later life survival as the findings from other countries are not consistent: In the Netherlands of the 19th century, increased survival after age 50 was found for farmers who could secure food for their families rather than the higher-class groups (Mourits, 2019); in pre-industrial Sweden, socioeconomic status had no significant effect for women and only men with unknown social position had increased mortality (Edvinsson &

Broström, 2012), while in pre-industrial Finland, the poorest women had the lowest age-specific survival throughout their lives (Pettay et al., 2007).

There are at least two reasons to consider the region of birth in relation to presence of kin and survival of older people in Finland. First, researchers point to the differences in mortality for people born in the West and East of the country, and survival benefits between East and West may be genetically driven (Saarela & Finnäs, 2011). The main genetic division shows strong concordance with the 1323 borderline of the treaty of Nöteborg (Kerminen et al., 2017). Second, household compositions varied in the pre-industrial period: In western Finland stem-families were common while in eastern Finland multiple family households with horizontal extension (joint families of adult brothers) could be frequently found (Moring, 1998). These differences could have led to caregiving strategies that differed in the effectiveness of the care of older adults. Regarding the period of birth, we focus on individuals born from 1740 to 1859, a time before the country's industrialization (Hjerppe, 1989), the onset of the demographic transition (Scranton et al., 2016), and development of the railway system (Martí-Henneberg, 2013) that related to higher dispersal rates in Finland (Kauppi et al., under review). For those who were born closer in time to these events, the survival probabilities are expected to be higher than for those born in 1740.

Data and methods

Data selection

For this study, we employed genealogical records from historical population registers and published genealogies from Finland. The population registers were collected by the Lutheran church, and they cover major events such as births, deaths and marriages. From genealogical records, individual life-histories and lineages were reconstructed. The original lineages start from eight parishes in four major regions in the beginning of 18th century: Southwest Finland (Hiittinen, Rymättylä, and Kustavi); Pirkanmaa region (Ikaalinen and Tyrvää); Northern Ostrobothnia (Pulkkila); and Karelian parts (Jaakkima and Rautu). This data subset covers different regions of Finland and can therefore be considered as broadly representative of the whole population (Chapman & Lummaa, 2024).

Our study population was limited to individuals born in Finland from 1740 to 1839. Since we were interested in the role of kin in later life, we focused on people who reached the age of 50 years. The resulting working sample included 54,967 person-years belonging to 3,360 men nested within 2,338 pairs of common parents and 64,251 person-years belonging to 3,540 women nested within 2,356 common parents.

Variables

Survival of each focal individual was coded as a binomial time-varying variable, dead (0) or alive (1), at each age from 50 to 90 years, based on exact death dates. Individuals without a recorded date of death were censored at the last age they were known to be alive. *Age* in years was included as a continuous covariate.

The main explanatory time-varying variables included *having children, siblings and grandchildren alive*. For constructing these variables, we used information about the kin of each type who were certainly alive and did not include kin for whom the date of death was unknown. It means that people in our sample may have had more family members alive, but we do not know about them. However, the numbers of censored kin are modest: At the age of 50, the mean numbers were equal to 0.19 children (SE = 0.007), 0.63 siblings (SE = 0.013) and 0.01 grandchildren (SE = 0.001).

We analyzed both (i) the vital status of family members and (ii) the sex and number of alive children or siblings. The first operationalization for children distinguished between having at least one child alive (1) or not having any children alive (0 – the reference category). The variable indicating the vital status of siblings was generated in a similar way. The second operationalization included six categories for children: no children alive (0 – the reference category), only one daughter alive (1), only one son alive (2), more than one daughter and no sons alive (3), more than one son and no daughters alive (4), several children of different sex alive (5); and six similar categories for siblings: no siblings alive (0 – the reference category), only one sister alive (1), only one brother alive (2), more than one sister and no brothers alive (3), more than one brother and no sisters alive (4), several siblings of different sex alive (5). Because the presence of grandchildren is conditional on having children, the presence of the former was operationalized in two ways: i) in the model that does not adjust for the presence of children as 'having at least one grandchild alive' (1) or 'not having any grandchildren alive' (0 – the reference category); and ii) in combination with the presence of children as 'neither having children, nor grandchildren alive' (0 – the reference category), 'having at least one child but no grandchildren' (1), 'having at least one grandchild but no children alive' (2), 'having both a at least one child and at least one grandchild alive' (3).

We also operationalized the presence of a spouse in three ways. The first one included four categories: was married but certainly no spouse alive (0 – the reference category), a spouse alive (1), never married (2), was married but spouse death date is unknown (3). The second and third operationalizations were required for testing the family embeddedness hypothesis and were defined as simple spouse presence: 'not having a spouse alive' (0 – the reference category; included 'never married') and 'having a spouse alive' (1); and combination between spouse's and child's presence:

'having neither a spouse, nor a child alive' (0 – the reference category) and 'having a spouse, a child or both alive' (1)

In all models, we controlled for individuals' socioeconomic status, order of birth, internal migration experience, region of birth, and 20-year birth cohort. Categorization into two socioeconomic statuses—landholders (1) and landless (0 – ref.)—was performed based on occupation (for a more precise explanation of the statuses see Salonen et al. (2024)). We indicated whether a person was the first or the only child in the family (1) or not (0 – ref.). We also specified whether a person ever left the parish of birth (1) or not (0 – ref.). We distinguished between the West (1) and East (0 – ref.) as a region of birth using the 1323 borderline of the treaty of Nöteborg (Kerminen et al., 2017). The control variables mentioned above also included a category 'unknown'. The birth cohort variable consisted of six categories: 1740-1759, 1760-1779, 1780-1799 (ref.), 1800-1819, 1820-1839, 1840-1859.

Analytical strategy

First, for our study population consisting of men and women at the age of 50-90 years, we calculated the proportions of those with at least one child and at least one sibling alive as well as their average numbers of living sons, daughters, brothers, and sisters (Figure 1).

Second, to analyze the role of living children and siblings in survival, we employed discrete-time hazard models from a series of one-year observations constructed for each individual (Table 1). The first year of this series was when the person turned 50 years old. The last year of observation was at age 90, the year of death, or the year when the individual was seen in the records alive the last time, whichever came first. The age of 90 was selected because for the majority of individuals in our sample population the death occurred by this age (Supplementary Materials, Figure S1), although the maximum ages of death equaled 97 years for men and 98 years for women. The first (individual) level was defined by the individual's ID. Each one-year observation included information on having a family member of a particular type (a child, a sibling, a spouse) alive. The one-year observations also included information on whether the person died within the year. Logistic regression models for the probability of death within a year were estimated from the resulting series of one-year observations. This procedure allowed variables, such as which family members were alive each year or not, to change through time. To adequately account for clustering of older men and women within their parents who, theoretically, could pass the survival advantage or disadvantage on to their offspring (Mourits et al., 2020), we applied multilevel random intercepts models. The second (parental) level was defined by the joint mother-father's ID. Finally, because the mortality patterns

of men and women differed (Figure S1), the models were stratified by sex. Stratifying the sample by sex also enabled us to avoid potential correlated outcomes between partners.

Third, we included the interaction between age of older individuals and having kin alive to account for possible differences in the effect of having supportive or, alternatively, competing relations by age (Table 2). Additionally, we explored the interaction between having a spouse and other kin alive to test the family embeddedness hypothesis. Statistical significance of interactions was obtained using likelihood ratio tests and reported as chi-square tests (Table S2). Finally, we ran models for the presence of grandchildren.

Besides the main models, we explored how different operationalizations of the number of children and siblings at different life course stages as well as having parents alive were associated with later life survival. Additionally, we ran separate models, which included the presence of children plus control variables and presence of siblings plus control variables.

Results

Presence of children, siblings and grandchildren in later life

Around 80% of older adults at the age of 50, i.e. in the beginning of the observation period, had at least one child (mean = 3.14, SD = 2.48) and at least one sibling (mean = 2.20, SD = 1.79) alive (Figure 1). It was uncommon to have only one child or one sibling alive, or only children and siblings of the same sex alive in later life (Table S1). Many had a mixed sex group of living children (52 percent of men and 44 percent of women) and siblings (32 percent of men and 30 percent of women) over the observation window. The number of living children and siblings as well as the presence of at least one representative of these family members decreased with individuals' age and the decrease was much more pronounced for siblings than children (Figure 1). The trends were similar for men and women. Concerning grandchildren, at the age of 50, 18% of men and 26% of women had at least one grandchild and a half of people in our sample became grandparents by the age of 60 (Figure 1). The average numbers of alive kin at the age of 50 gradually increased over time: From 2.7 children for those born in 1740-1759 to 3.5 children for those born in 1840-1859; from 1.6 to 2.2 siblings and from 0.4 to 0.5 grandchildren respectively.

Men **Women**

Children

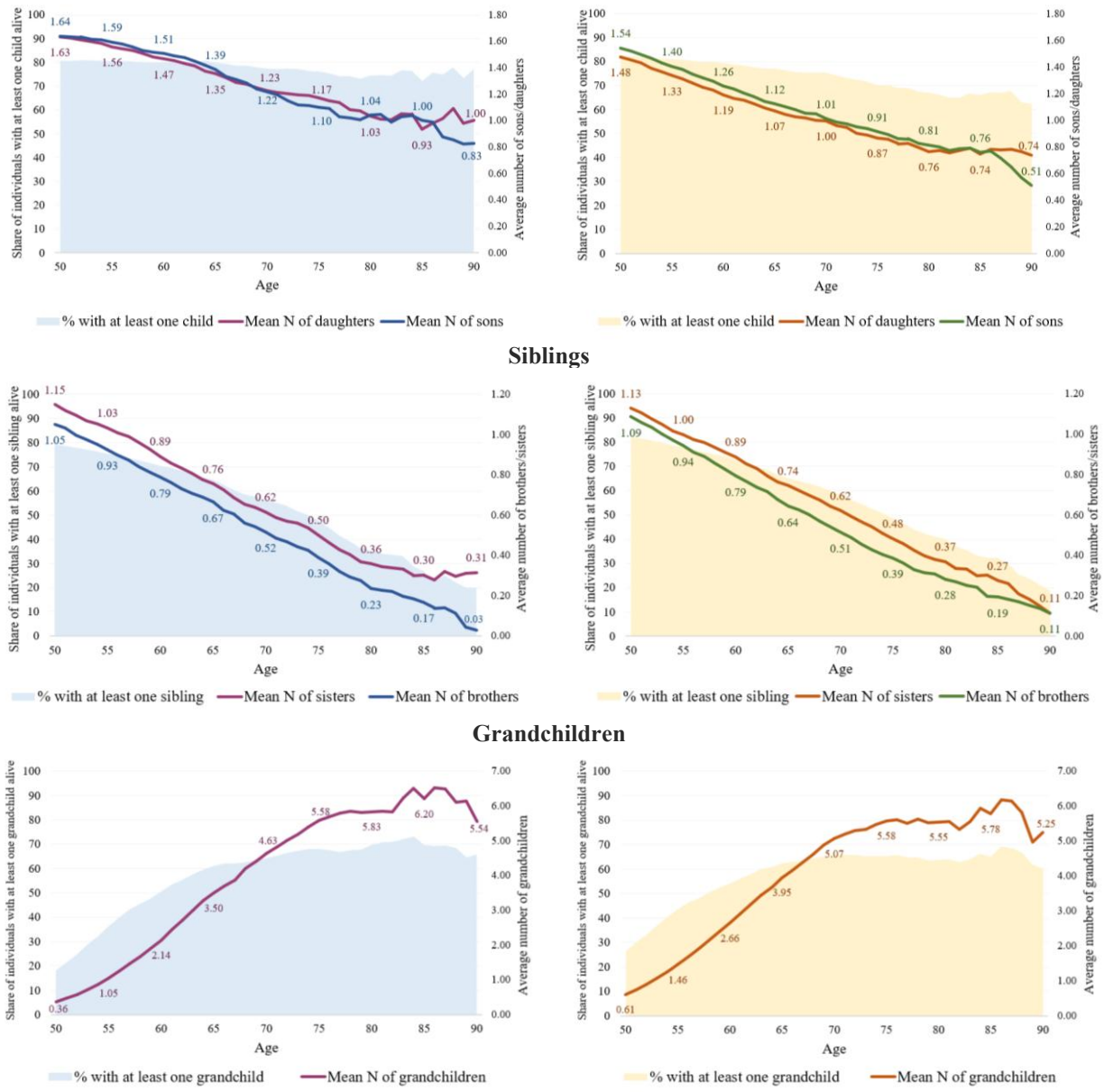

Figure 1. Presence of children, siblings and grandchildren in later life

Presence of children and siblings and the risk of death in later life

We hypothesized (Hypothesis 1) that having children or siblings alive would reduce the risk of death after age 50 but found only limited support for this hypothesis. Relative to those with no children present, men with at least one child alive had a lower risk of death although the effect[1] was statistically significant only at the 10% level (OR = 0.894). Our models do not point to statistically significant differences in risks of death for men and women with and without at least one sibling alive (Table 1).

Table 1. Odds ratios and 95% confidence intervals (CIs) from discrete-time models of associations between presence of kin and mortality, women and men aged 50–90 years

[1] The term "effect" is used to denote a statistical association without implying a causal relationship.

	Men	Women	Men	Women
Having at least one child alive (Ref: No)				
Yes	0.894†	0.938		
	(0.795 - 1.006)	(0.839 - 1.049)		
Sex and number of alive children (Ref: No children)				
Only one daughter alive			0.852†	1.022
			(0.708 - 1.025)	(0.867 - 1.206)
Only one son alive			1.098	0.889
			(0.920 - 1.310)	(0.754 - 1.048)
More than one daughter and no sons			0.970	0.929
			(0.792 - 1.188)	(0.757 - 1.141)
More than one son and no daughters			0.938	0.845
			(0.764 - 1.151)	(0.691 - 1.034)
Several children of different sex alive			0.850*	0.954
			(0.749 - 0.964)	(0.842 - 1.080)
Having at least one sibling alive (Ref: No)				
Yes	0.984	1.064		
	(0.893 - 1.084)	(0.960 - 1.179)		
Sex and number of alive siblings (Ref: No siblings)				
Only one sister alive			0.989	1.142†
			(0.861 - 1.137)	(0.992 - 1.314)
Only one brother alive			1.105	1.144†
			(0.944 - 1.293)	(0.987 - 1.327)
More than one sister and no brothers			0.983	1.035
			(0.822 - 1.176)	(0.845 - 1.268)
More than one brother and no sisters			0.986	1.024
			(0.777 - 1.251)	(0.818 - 1.281)
Several siblings of different sex alive			0.950	0.941
			(0.838 - 1.077)	(0.819 - 1.081)
Age	1.087***	1.106***	1.087***	1.104***
	(1.079 - 1.096)	(1.098 - 1.115)	(1.078 - 1.096)	(1.095 - 1.113)
Presence of a spouse (Ref: Was married but the spouse certainly passed away)				
Alive	0.783*	0.879†	0.780*	0.887
	(0.635 - 0.964)	(0.758 - 1.019)	(0.633 - 0.961)	(0.766 - 1.027)
Never married	0.857	1.148	0.851	1.157
	(0.652 - 1.125)	(0.915 - 1.440)	(0.647 - 1.120)	(0.923 - 1.450)
Was married but spouse death date unknown	0.753**	0.971	0.750**	0.964
	(0.611 - 0.929)	(0.828 - 1.139)	(0.607 - 0.926)	(0.823 - 1.130)
Socioeconomic status (Ref: Landless)				
Landholder	1.014	1.102†	1.024	1.105†
	(0.921 - 1.115)	(0.994 - 1.222)	(0.930 - 1.127)	(0.997 - 1.224)
Unknown	1.063	1.066	1.068	1.063
	(0.828 - 1.365)	(0.834 - 1.363)	(0.831 - 1.373)	(0.834 - 1.355)
Order of birth (Ref: Laterborn)				
The first-born or the only child	1.000	1.009	0.998	1.012
	(0.901 - 1.110)	(0.904 - 1.125)	(0.899 - 1.109)	(0.908 - 1.129)
Unknown	0.868	0.890	0.897	0.894
	(0.602 - 1.252)	(0.553 - 1.433)	(0.621 - 1.296)	(0.559 - 1.430)
Ever leaving the parish of birth (Ref: No)				
Yes	0.900†	0.888*	0.898†	0.894*
	(0.807 - 1.004)	(0.796 - 0.991)	(0.805 - 1.002)	(0.802 - 0.997)
Unknown	0.919	0.803	0.902	0.804
	(0.692 - 1.222)	(0.584 - 1.106)	(0.678 - 1.201)	(0.586 - 1.104)
Region of birth (Ref: East)				
West	0.825***	0.794***	0.815***	0.791***
	(0.743 - 0.916)	(0.707 - 0.892)	(0.733 - 0.906)	(0.705 - 0.887)
Unknown	1.632	0.887	1.685	0.909
	(0.333 - 8.007)	(0.274 - 2.869)	(0.340 - 8.357)	(0.283 - 2.921)
Birth cohort (Ref: 1780-1799)				
1740-1759	1.168	0.909	1.142	0.906

	Men	Women	Men	Women
	(0.901 - 1.515)	(0.680 - 1.217)	(0.879 - 1.484)	(0.680 - 1.208)
1760-1779	0.841†	0.766*	0.828†	0.771*
	(0.694 - 1.018)	(0.624 - 0.940)	(0.683 - 1.004)	(0.630 - 0.944)
1800-1819	0.993	0.956	0.982	0.941
	(0.857 - 1.150)	(0.817 - 1.118)	(0.848 - 1.139)	(0.805 - 1.099)
1820-1839	0.635***	0.624***	0.631***	0.631***
	(0.549 - 0.735)	(0.533 - 0.731)	(0.545 - 0.731)	(0.539 - 0.737)
1840-1859	0.606***	0.534***	0.601***	0.538***
	(0.519 - 0.709)	(0.450 - 0.632)	(0.513 - 0.703)	(0.455 - 0.636)
Constant	0.0005***	0.0001***	0.0005***	0.0001***
	0.004 (SE)	0.00002 (SE)	0.0001 (SE)	0.00003 (SE)
Variance of random effect: level of parents	0.113	0.272	0.120	0.244
	0.053 (SE)	0.064 (SE)	0.056 (SE)	0.064 (SE)
Log likelihood	-9444.6039	-9809.6947	-9437.1894	-9803.9814
Wald chi2(19/27), Prob > chi2	523.06, p <	759.53, p <	523.53, p <	769.58, p <
	0.001	0.001	0.001	0.001
Observations (person-years)	54,967	64,251	54,967	64,251
Number of deaths	2,483	2,542	2,483	2,542
Number of older adults	3,360	3,540	3,360	3,540
Number of groups (common parents)	2,338	2,356	2,338	2,356

Notes: *** p<0.001, **p<0.01, * p<0.05, † p<0.1

We also tested how the sex composition and number of children and siblings were associated with survival (Hypothesis 2). For men, the configurations that reduced the risk of death in comparison with having no living children were having one daughter alive (statistically significant at the 10% level: OR = 0.852) and having children of different sexes alive (OR = 0.850, $p < .05$). No evidence of differences in the risks of death of women with different sex composition and number of children were revealed in our models. For women, relative to having no siblings alive, having only one brother (OR = 1.144) or only one sister (OR = 1.142) was associated with increased risk of death at the 10% level. To nuance this result, we contrasted the category 'several siblings of different sex' with other configurations. Relative to a group of older women with a mixed sex group of siblings, those with only one sister (OR = 1.213) and only one brother (OR = 1.216) had a higher risk of death (significant at the 5% level). No similar differences were found for men.

We further hypothesized that the role of children and siblings for survival would increase by age (Hypothesis 3). The likelihood-ratio (LR) test results pointed to age variation for the effects of having alive siblings but not children (Table S2). At 50, the risk of death was higher for those who had at least one sibling alive relative to those not having siblings, but the trend reversed with increasing age (Table 3, Figure 2). For men, siblings became beneficial for survival at the age of 66, for women this change occurred later, namely, at the age of 73. Regarding the sex and number of siblings, relative to not having siblings alive, having one sister for men, a mixed sex group of siblings for women, and several sisters but no brothers for both became advantageous for survival with increasing age (Table 2 and Figure 2). This result partly confirms not only Hypothesis 3 but also

Hypothesis 2 by pointing to the advantage of having at least one sister or a mixed group of siblings available.

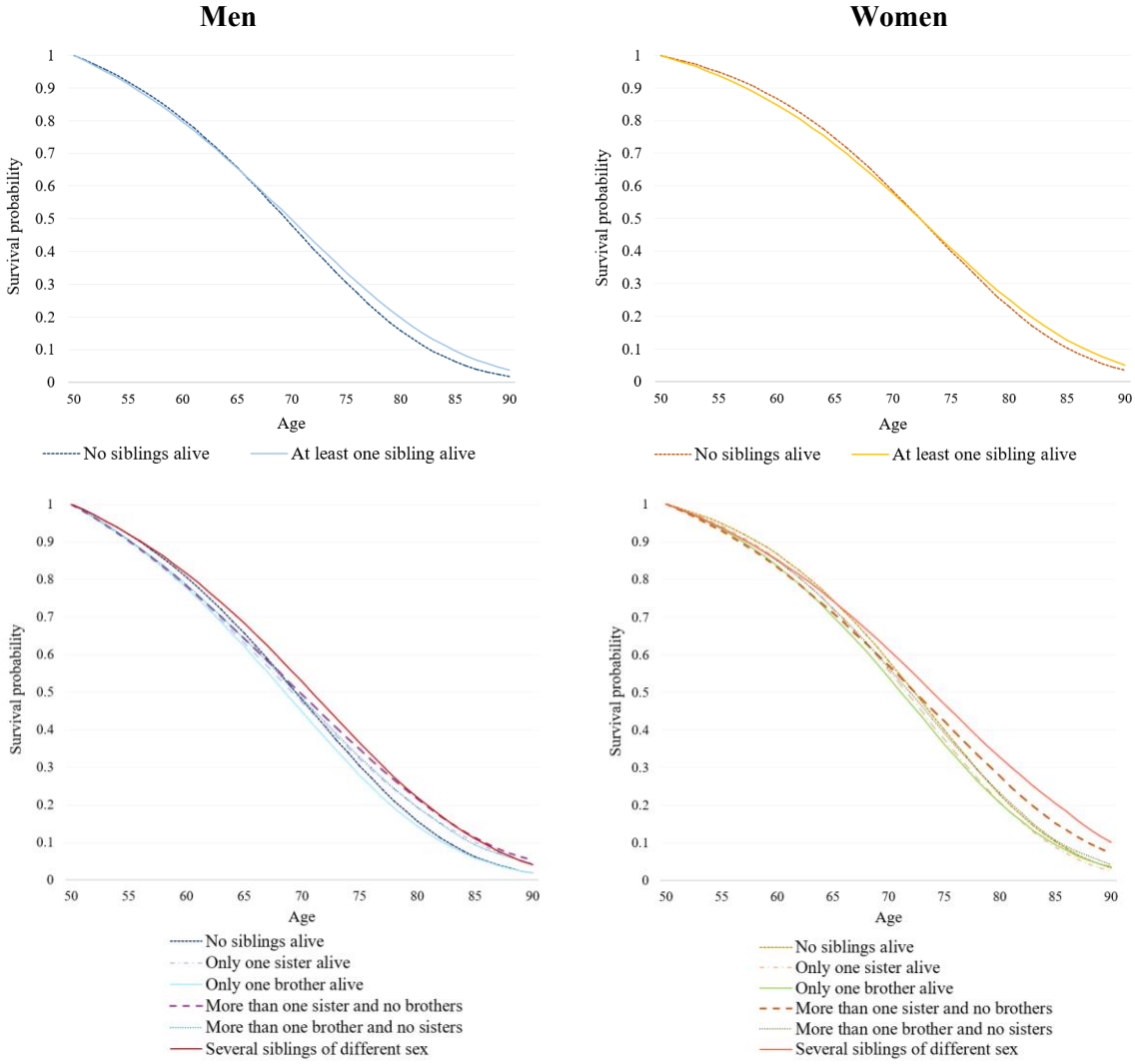

Figure 2. The role of siblings in later life survival by age

Table 2. Odds ratios and 95% CIs from adjusted discrete-time models of associations between the presence of siblings by age and mortality (age-interaction models), women and men aged 50–90 years

	Men	Women	Men	Women
	Main effects			
Having at least one sibling alive (Ref: No)				
Yes	2.155* (1.125 - 4.130)	2.421* (1.228 - 4.775)		
Sex and number of alive siblings (Ref: No siblings)				
Only one sister alive			3.881** (1.445 - 10.426)	1.300 (0.480 - 3.522)
Only one brother alive			1.697 (0.554 - 5.201)	2.213 (0.769 - 6.369)
More than one sister and no brothers			3.893* (1.112 - 13.631)	5.324* (1.453 - 19.511)

More than one brother and no sisters			3.178	2.318
			(0.613 - 16.483)	(0.447 - 12.039)
Several siblings of different sex alive			1.568	5.049***
			(0.674 - 3.646)	(2.051 - 12.428)
Age	1.095***	1.115***	1.096***	1.115***
	(1.084 - 1.107)	(1.104 - 1.127)	(1.085 - 1.108)	(1.103 - 1.127)
Interaction terms				
Having at least one sibling alive (Ref: No) * age				
Yes	0.988*	0.988*		
	(0.979 - 0.998)	(0.979 - 0.998)		
Sex and number of alive siblings (Ref: No siblings) * age				
Only one sister alive			0.980**	0.999
			(0.965 - 0.994)	(0.985 - 1.013)
Only one brother alive			0.994	0.991
			(0.977 - 1.011)	(0.976 - 1.006)
More than one sister and no brothers			0.979*	0.976*
			(0.960 - 0.998)	(0.957 - 0.996)
More than one brother and no sisters			0.982	0.988
			(0.957 - 1.008)	(0.963 - 1.014)
Several siblings of different sex alive			0.993	0.975***
			(0.980 - 1.006)	(0.962 - 0.988)
Constant	0.0003***	0.00005***	0.0003***	0.00005***
	0.0001 (SE)	0.00002 (SE)	0.0001 (SE)	0.00002 (SE)
Variance of random effect: level of parents	0.130	0.291	0.141	0.280
	0.057 (SE)	0.067 (SE)	0.059 (SE)	0.070 (SE)
Log likelihood	-9441.6952	-9806.7599	-9431.72	-9794.8433
Wald chi2(20/32), Prob > chi2	505.62, p < .001	745.14, p < .001	518.50, p < .001	753.20, p < .001
Observations (person-years)	54,967	64,251	54,967	64,251
Number of deaths	2,483	2,542	2,483	2,542
Number of older adults	3,360	3,540	3,360	3,540
Number of groups (common parents)	2,338	2,356	2,338	2,356

Notes: *** p<0.001, **p<0.01, * p<0.05, † p<0.1

Furthermore, we tested the family embeddedness hypotheses suggesting that the role of living children and siblings for survival would be greater when a spouse is absent (4a) and the role of living siblings would be greater when both a spouse and children are absent (4b). For this, we employed a sample that excluded individuals whose spouses' death date was unknown and, as a result, included 27,264 person-years of 1,533 men and 37,532 person-years of 1,907 women. Relative to being married but not having a spouse alive any longer, men with a living spouse had a lower risk of death (Table 1). As for women, having a spouse alive was associated with lower mortality while never being married was associated with higher risk of death, although the estimates were not statistically significant at the 5% level. The models that included interactions between the presence of a spouse and having children and siblings alive did not have a higher value of model-fit than the models without these interactions (Table S2). These LR test results imply no evidence of variation in the effects of having living children and siblings (with both operationalizations of this concept) on the risk of death by the presence of a spouse either for older men or women.

We also formulated the alternative Hypothesis 5 saying that having several living sons for women and several living brothers for men relative to having no kin of these types would be

associated with an increased risk of death. Our models do not show support for this hypothesis. In addition, we switched our reference categories to 'having one daughter' and 'having one sister' respectively and found several associations statistically significant at the 5% and 10% level. First, relative to having one daughter; having one son (OR = 1.288, $p = .017$) and having no alive children (OR=1.173, $p = .090$) was associated with higher risk of death for older men and having several sons but no daughters was associated with lower risk of death for older women (OR = 0.826, $p = .095$). Second, relative to having one sister, having a mixed-sex sibling group (OR = 0.824, $p = .016$) and having no siblings (OR = 0. .875, $p = .064$) was associated with lower risk of death for women.

Finally, we broadly hypothesized that having grandchildren would be associated with the risk of death (Hypothesis 6). Our models suggested that the presence of at least one grandchild mattered for older men's but not for older women's survival (Table 3). Relative to those men who had neither children nor grandchildren alive, having at least one grandchild irrespective of the presence of a child was associated with a lower risk of death. However, the estimate was statistically significant at the 5% level only for those men who had both at least one child and at least one grandchild alive (OR = 0.848, $p = .011$).

We employed multilevel random intercepts models to account for clustering of older men and women within their parents. The intra-class correlation coefficients (ICC) of the models that include only age as a predictor showed that 5.9 percent of the variance in the risk of death for older men and 7.8 percent of this variance for older women were attributable to the parental level. Although the portion of variable attributable to this level is small, LR tests suggest that multilevel models are preferable (LR $\chi 2$ (1) equal to 16.48, $p < .001$ for men and LR $\chi 2$ (1) equal to 29.90, $p < .001$ for women). Including our explanatory and control variables reduced the variance in the outcome attributable to the parental level to 3.3 percent for men and 7.6 percent for women.

Table 3. Odds ratios and 95% CIs from adjusted discrete-time models of associations between the presence of grandchildren and mortality, women and men aged 50–90 years

	Men	Women	Men	Women
Having at least one grandchild alive (Ref: No)				
Yes	0.890*	0.956		
	(0.810 - 0.980)	(0.876 - 1.054)		
Combination of the presence of children and grandchildren (Ref: No children and no grandchildren)				
At least one grandchild but no children alive			0.686†	1.145
			(0.458 - 1.052)	(0.828 - 1.584)
At least one child but no grandchildren alive			0.913	0.980
			(0.791 - 1.053)	(0.843 - 1.138)
Both at least one child and grandchild alive			0.848*	0.942
			(0.746 - 0.963)	(0.835 - 1.063)
Constant	0.0004***	0.0001***	0.0004***	0.0001***
	0.0001 (SE)	0.0001 (SE)	0.0001 (SE)	0.0001 (SE)

Variance of random effect: level of parents	0.118 0.054 (SE)	0.275 0.065 (SE)	0.113 0.054 (SE)	0.274 0.065 (SE)
Log likelihood	-9443.491	-9809.9105	-9442.0914	-9809.1553
Wald chi2(19/21), Prob > chi2	524.28, p < .001	758.23, p < .001	526.11, p < .001	758.60, p < .001
Observations (person-years)	54,967	64,251	54,967	64,251
Number of deaths	2,483	2,542	2,483	2,542
Number of older adults	3,360	3,540	3,360	3,540
Number of groups (common parents)	2,338	2,356	2,338	2,356

Notes: *** p<0.001, **p<0.01, * p<0.05, † p<0.1

As for the control variables, our models pointed only to the effects of leaving a parish of birth, region of birth, and birth cohort on the risk of death in later life. Being born in the West of the country, experiencing internal migration, and being born after 1820 were associated with a lower risk of death.

Additional and sensitivity analyses

As not only the presence of kin during aging but also kin that individuals had earlier in life might matter for survival (see, for example, Dribe (2004) for the role of children), a series of sensitivity checks (Table S3) on different operationalizations of the number of children and siblings at different stages of the life course was performed: i) the total number of living children and siblings, ii) the number of children and siblings that individuals ever had, and iii) the presence of alive children and siblings relative to the initial number of these family members. First, we found that the more living children and siblings (included in the models as two numeric variables) one had in later life, the lower the risk of death was, although the estimate was statistically significant only for the number of children for men at the 10% level (OR = 0.981, $p = .074$). Second, regarding the initial number of children, the models did not support statistically significant association between ever having 1, 2, 3+ children (relative to 'no children') and survival for men. Giving birth to only two children relative to remaining childless was associated with increased risk of death for women but the effect was significant only at 10% level (OR = 1.232, $p = .074$). Models did not point to statistically significant differences in the risk of death in later life by the number of siblings individuals ever had. Third, regarding the presence of living children and siblings in comparison with the initial number of these family members, we found that giving birth to children but not having them alive in later life relative to never giving birth was associated with increased risk of death for women, the effect was statistically significant for initially having 1-2 children at 5% level (OR = 1.280, $p = .044$) and for initially having more than two children at the 10% level (OR = 1.230, $p = .092$). Interestingly, if we change the reference category to 'Initially having more than two and at least one now', relative to it, (a) those women who initially had more than two and have no children in later life and (b) those who had 1-2 and have no children in later life had a higher risk of death (OR = 1.184, $p = .070$ and OR = 1.232, $p = .036$ respectively). No evidence of similar effects was found for men. As for siblings, we found

that relative to never having siblings, initially having more than two siblings but none of them alive (OR = 1.332, $p = .012$) or at least one of them alive (OR = 1.202, $p = .086$) in later life was associated with increased risk of death for men but not for women.

Parents are other family members whose vital status might relate to survival in later life: Individuals seem to pass their longevity on to their offspring and, therefore, having long-lived fathers and mothers potentially makes individuals more likely to become long-lived themselves (Mourits et al., 2020). At the age of 50, around 22% of individuals had at least one parent alive but the share of such individuals reached zero at the age of 74 for men and 80 for women (Figure S2). The models (Table S4) that included parental vital status showed that having at least one parent alive was associated with decreased risks of death although the estimate was significant for men and at the 10% level only (OR = 0.823, $p = .081$). It is possible that our findings about the benefit of having at least one sibling alive with increasing age can be explained by siblings' mutual inherited survival benefit rather than support exchange as, for example, siblings of centenarians were found to have a significant mortality advantage compared to the average population (Perls et al. 2002). To explore whether the advantage of having siblings in later life is explained by the mutual family survival advantage, we ran models that included an interaction between having at least one sibling alive and age plus control variables and added the variable about having at least one parent alive (Table S4). These models did not suggest any mediation effect of having a parent alive on the relationship between age, having a sibling alive and survival.

Another sensitivity check explored the stability of our models for the reduced sample that excluded individuals with missing values in control variables (50,934 person-years nested within 3,126 men and 59,368 person-years nested within 3,290 women). The only difference in the estimates of the main explanatory variables on the risk of death was that the effect of having at least one child alive for men and effects of having only one brother or only one sister for women become smaller and turn from significant at 10% level to non-significant (Table S5).

Finally, we ran models that tested the effects of the presence of children and siblings separately (Table S6). The estimates of these reduced models did not substantially differ from the full models presented in Tables 1.

Discussion

As humans are a highly social species, helping behavior is likely to be an ancestral part of our natural behavior, not merely a product of current western societies. Our sociality is known to drive our life history evolution (survival and reproduction) as well as evolution of our long lifespans (by grandmothering (see, for example, Kim et al., 2012). However, there is a limited number of studies

in historical societies investigating the survival of older people mainly because, in the evolutionary sense, their well-being and survival are not considered important due to the small contribution of older age survival to a person's evolutionary fitness (genes passed on to next generation). In this study, we aimed at identifying the presence of older adults' children, siblings and grandchildren as well as exploring the relationship between having these family members alive and later life survival in the pre-industrial population of Finland. By focusing on the presence of kin in the process of aging rather than the lifetime presence of these family members, we tried to capture the supportive role of the family for older adults. At the same time, we considered the possibility of competition for family resources as an alternative mechanism shaping the association between kin and mortality.

We found that around 80% of older adults at the age of 50 had at least one child and at least one sibling alive. The number of these family members decreased with time, especially the number of siblings. At the age of 50, 18% of men and 26% of women had at least one grandchild and a half of people become grandparents by the age of 60. Our results provided only limited support for the set of family caregiving hypotheses, posited that the presence of kin, especially daughters and sisters, would reduce mortality risks. Simply the presence of at least one child or sibling was not associated with the risk of death at the 5% level. However, the odds of dying were associated with kin sex constellations and age. Lower mortality was observed for men who had several children of different sex alive, perhaps because sons and daughters can provide different types of support (Rossi & Rossi, 1990). At 50, having at least one sibling alive was associated with increased risk of death but siblings became beneficial for survival at the age of 66 for men and 73 for women, supporting the idea that sibling cooperation intensifies as health declines (Connidis, 1992; Gold, 1987). Notably, having a mixed-sex sibling group or multiple sisters was particularly beneficial for survival in later life. This finding might suggest that sibling relationships serve as an important safety net when needed, warranting further exploration into how sibling ties evolve over the later life. Interestingly, for women, having only one living sibling—either a brother or a sister—was associated with a slightly higher risk of death. Furthermore, we did not find support for the family embeddedness hypothesis e.g., variations in the effects of having living siblings on the risk of death by the presence of a spouse and children. The lack of such effects in our study may reflect the specific socioeconomic and familial structures in pre-industrial Finland, where, for example, sibling cooperation in later life may have outweighed competition irrespective of presence of closer family members.

Neither we found support for our alternative (competition) hypothesis predicting that having multiple sons for women or multiple brothers for both men and women would increase the risk of death. Because the competition for family resources at earlier stages of the life course rather than in later life could shape the association between kin and mortality, we ran additional analyses with

different operationalizations of access to kin that include the numbers of children and siblings that individuals ever had and comparison between initial and present number of these family members. The models did not point to statistically significant association between the numbers of siblings and children that individuals ever had and survival. However, giving birth to children but not having them alive in later life (relative to never giving birth) was associated with increased risk of death for women only. As for siblings, initially having more than two siblings but none of them alive in later life relative to never having siblings was associated with increased risk of death for men only. These results might echo the competition for family resources from earlier stages of individuals' lives (with children for women as in pre-industrial Belgium (Van de Putte et al., 2004) and Sweden (Dribe, 2004) and with siblings for men as in pre-industrial Belgium (Donrovich et al., 2014)). For women, children were likely costly health-wise (Ryan et al., 2024) and perhaps support the living children could provide in later life did not compensate for the negative effects of rearing them, while men could get the benefits of children's support without the costs for health. Also, we speculate that if a woman gave birth, but the children did not survive, she probably either had to invest even more into their care to the detriment of her health or she was initially in poorer socioeconomic position and that did not favor survival of children. Future research could focus on the relationship between the death of children or siblings and survival at different life course stages in historical contexts. Important note from previous findings about the negative effect of children on women's survival concerns the disadvantaged socio-economic position of affected women (Van de Putte et al., 2004; Dribe, 2004). There could be a similar mechanism for men and their siblings: Having many siblings earlier in life led to higher competition and possible support from them in later life could not compensate for it, except the critical situations when sibling competition was found to be replaced by solidarity (Donrovich et al., 2014). Future research should further explore interplay between kin presence and survival for the representatives of different socioeconomic groups in Finland.

Finally, we broadly hypothesized that the presence of grandchildren would be associated with later-life survival and found inconsistent effects for men and women. Surprisingly, a survival benefit of having at least one grandchild appeared for men but not for women. If we assume that, as proposed by Garay et al. (2018), adult children invest more in older parents in exchange for grandparental help, then grandparents are expected to get the survival benefit of having grandchildren. Finding the effect of having a grandchild—more precisely, having at least one child and grandchild but not childless adult children—only for men can suggest that the increased support from children is beneficial for men but perhaps cannot compensate for efforts that (mainly) grandmothers spent on burdensome care for grandchildren. This speculation is in line with research from contemporary populations showing that providing some grandparental care improves the health of older adults except for grandmothers

who provide burdensome daily care to their grandchildren (Leimer & Van Ewijk, 2022). Additionally, as having a grandchild is conditional on having children which is costly for women's health, men might enjoy the survival benefit of grandchildren without costs. It is plausible that distinguishing between daughters' and sons' children will nuance the relationship between having grandchildren and survival; future studies should focus on this.

This study has limitations that need to be considered when interpreting our results. First, since we look only at the living statuses of the kin, our estimates are likely conservative. While our dataset provides valuable insights into kinship structures and mortality in pre-industrial Finland, it does not capture the qualitative aspects of family relationships, such as the quality of support or emotional bonds. Our dataset also lacks geographic proximity of kin that could be used as a proxy for support exchange. The presence of kin does not necessarily equate to active caregiving, and future research based on historical data could incorporate geographic proximity as a more reliable proxy of support exchange to assess the nature of these relationships. Second, in relation to utilizing information on the presence of kin, it needs to be remembered that we considered only relatives who were certainly alive simultaneously with older adults. It means that the reference category was having no living relatives, while these relatives could have been alive but censored (as in the study by Lahdenperä and colleagues (2025) who explain why it is not a big issue) which could still have (a little) impact on our results. Third, the effects of the presence of kin might vary with the characteristics of children and siblings, such as their personality, health, and family situation, that we were unable to capture. Fourth, our study is limited to those who survived to age 50, potentially introducing a survivorship bias. The role of kinship support may have differed for those who died at younger ages, an aspect that could be explored separately. Fourth, while the amount of care provided depends on the needs that older people have (Kalmijn & Saraceno, 2008), we did not have information about health or, at least, the modern causes of death. Even when a cause of death was recorded in a limited number of cases, 'old age' was often mentioned. Moreover, lifestyle preferences and health earlier in life are important controls on which we have no information.

Our findings broadly contribute to the understanding of family dynamics and survival in historical populations. The lack of a consistent survival benefit from having kin alive in later life suggests that the protective effects of family networks are not universal and may depend on various factors, perhaps including social norms, economic conditions, and individual health status that we could not capture. However, our results highlight the complex role of family networks for later-life survival in pre-industrial populations, emphasizing the need to consider the sex composition of the family and kin availability (beyond spouses and children) at different stages of ageing. Our results about the increasing benefit of having siblings align with contemporary discussions on the role of

social networks in aging populations and suggest that sibling ties could be an underexplored dimension of later-life support (Jensen et al., 2020; Artamonova & Gillespie, 2023). Importantly, to the best of our knowledge, it is the first study that focused on the role of grandchildren for survival of older adults in pre-industrial Finland. The effect that was found for older men might signal about adult children's increased investment in older parents if they have their own children and need grandparental childcare as Garay and colleagues (2018) suggest. The role of grandchildren for survival of older men and women in historical and modern populations requires further research. Clarifying how the presence of close kin and, if possible, additional relatives (e.g., nieces and nephews) relates to survival in historical contexts can offer insights into the evolution of the family.

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